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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the Patent Application of

Shiichi FUKUDA

Serial No. 09/512,336

Filed: February 24, 2000

For: DRY ETCHING METHOD AND  
METHOD OF MANUFACTURING  
SEMICONDUCTOR APPARATUS

Group Art Unit: 1765

Examiner: K. Chen

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RESPONSE

Commissioner of Patents  
Washington, DC 20231

Sir:

This is a full and timely response to the non-final Official Action mailed December 31, 2001. A petition for a two-month extension of time and the requisite fee accompany this paper. Reexamination and reconsideration in light of the following remarks are courteously requested.

Claims 1 to 8 are currently pending for the Examiner's consideration. The Examiner rejected claims 1 to 3 under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,146,542 issued to Ha et al. ("Ha") in view of U.S. Patent No. 5,164,330 issued to Davis et al. ("Davis"). The Examiner also rejected claims 4 to 8 as being unpatentable over Ha in view of Davis and U.S. Patent No. 6,296,780 ("Yam"). These rejections are respectfully traversed.

By way of introduction to the arguments, it is explained that the present invention is directed to the use of a very



particular combination of gases for the purpose of dry etching a metal having specific properties such as those of tungsten, and for making a semiconductor apparatus using the same combination of gases. The background section of the present application teaches that the combination of gases is important, as none of the gases alone is sufficient to accomplish the purposes of the inventive methods. There is no doubt that the individual gases used in the etching combination are not new themselves. There is also no doubt that some of these gases are well known to be used in combination for the purpose of etching tungsten. However, as will be established below, the exact combination of gases in the methods of the present invention is new, and there is no teaching or suggestion in the prior art of record for combining the known gases in the manner that the present inventors conceived.

The Ha patent teaches a combination of gases for etching tungsten, with the major exception being that Ha's combination fails to specifically teach that a dry etching mixed gas includes a fluorocarbon. Rather, the Ha patent teaches in its background section that etching of tungsten is performed using fluorine compounds that do not contain carbon, including a mixture of  $\text{SF}_6$  and  $\text{NF}_3$ . The passage of Ha cited by the Examiner simply reads that a fluorine compound is used to etch tungsten layers, but it would be inferred by a person of skill

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in the art that the same compounds cited in the background section for this process would be used according to the Ha invention.

This point is further established by the fact that Ha goes on to disclose that a carbon-containing fluorine compound could be used in a subsequent etching step to remove **not the tungsten layers**, but the diffusion barrier layer (column 4, lines 5 to 8). Therefore a person of ordinary skill in the art would read Ha and ascertain that Ha suggests that a carbon-fluorine type etching gas could be used in diffusion barrier layer etching steps, but that Ha's tungsten etching step is performed using a combination of gases that includes the presently claimed gases, with the replacement of one or more of  $\text{SF}_6$  and  $\text{NF}_3$  for the claimed carbon-containing fluoride gas.

Consequently, in order for the present invention to be rendered obvious, there must be some teaching somewhere in the prior art that Ha's etching gas combination should replace  $\text{SF}_6$  and/or  $\text{NF}_3$  with a carbon-containing fluoride gas.

Davis clearly fails to suggest such a replacement. The Examiner asserts in part 4 of the Office Action that Davis's disclosure of carbon-containing fluoride compounds establishes that the compounds are known, implying that knowledge of the use of such compounds as tungsten etching agents is sufficient motivation for the replacement of Ha's  $\text{SF}_6$  and/or  $\text{NF}_3$  with a

carbon-containing fluoride gas. However, it is again emphasized that the present invention is not directed to a single etching gas, but a very particular combination of gases. The replacement of one gas for another in a particular combination of gases, like the Ha combination, must be done with some motivation, and the broad assertion that one gas is known tungsten etchant is not sufficient motivation to use it as a replacement for another gas, especially when there is no teaching or suggestion that the particular combination is in any way deficient or in need of improvement.

Further, a person of ordinary skill in the art would read the context of Davis's citation of carbon-containing fluoride gases, and clearly be steered away from making such a replacement. Davis teaches away from using fluorocarbon compounds as primary etching gases due to their tendency to cause carbon contamination that builds up on reactor walls and on an electrode in an etching chamber (col. 2, lines 36 to 43). Thus, Davis teaches that inorganic fluoride compounds such as  $\text{NF}_3/\text{Ar}$  mixtures should be primarily used "to remove the bulk of a tungsten film" followed by smaller etch steps that may include fluorocarbon compounds (col. 8, lines 22 to 29).

To summarize, the present invention involves using the fluorocarbon compound in a gas mixture of oxygen, nitrogen, and a chlorine or hydrogen bromide compound to remove an entire layer of tungsten, and in another embodiment, to also

remove an underlayer of tungsten nitride or titanium nitride. As established above, the person of ordinary skill in the art would not find motivation in the prior art to combine the known gases in the manner that is presently claimed, and would in fact be deterred from reaching the combination due to the explicit teachings of Ha and Davis. A reference must be considered for all it teaches, including disclosures that teach away from the invention as well as disclosures that point toward the invention. *Ashland Oil, Inc. v. Delta Resins & Refractories, Inc.* 776 F.2d 281, 227 U.S.P.Q. 657 (Fed. Cir. 1985). Consequently, the claims are not obvious, and the rejections of claims 1 to 8 should be withdrawn.

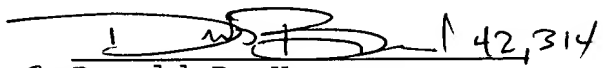
The Yan reference fails to compensate for the deficiencies of Ha and Davis. Yan mentions that carbon-containing fluoride gas may be used to process a substrate including an OARC layer and a TiN ARC layer, but makes no mention of using the claimed combination of gases for etching tungsten. Therefore, the combination of Ha, Davis, and Yan does not teach or suggest the method of the present claims.

For the foregoing reasons, all the claims now pending in the present application are believed to be clearly patentable over the prior art of record. Accordingly, favorable reconsideration of the claims in light of the above remarks is courteously solicited. If the Examiner has any comments or suggestions that could place this application in even better

form, the Examiner is requested to telephone the undersigned attorney at the below-listed number.

Respectfully submitted,

DATE: June 7, 2002

  
Ronald P. Kananen  
Registration No. 24,104

**RADER, FISHMAN & GRAUER, PLLC**

Lion Building  
1233 20<sup>th</sup> Street, N.W.  
Washington, D.C. 20036  
Tel: (202) 955-3750  
Fax: (202) 955-3751  
Customer No.: 23353